

WHAT IS CLAIMED IS:

1. An evaluation mask for evaluating a projection-type exposure apparatus, the mask comprising:

5 at least one diffraction grating pattern for producing a diffracted light of the positive first-order and a diffracted light of negative first-order, diffraction efficiencies of the diffracted lights being different respectively, one of the diffracted lights
10 having a magnitude that is substantially zero, and an image of the at least one diffraction grating pattern being projected onto a test substrate or an image detector by the projection-type exposure apparatus; and

 a reference pattern for obtaining a reference
15 image to measure a displacement of the image of the at least one diffraction grating pattern, and an image of the reference pattern being projected onto the test substrate or the image detector by the projection-type exposure apparatus,

20 wherein the images of the at least one diffraction grating pattern and the reference pattern projected onto the test substrate or the image detector are used for evaluating the projection-type exposure apparatus.

2. The evaluation mask according to claim 1,
25 wherein

 the reference pattern includes a diffraction grating pattern that is symmetric relative to the

diffraction grating pattern.

3. The evaluation mask according to claim 1,
wherein

5 the reference pattern includes a first reference
pattern and a second reference pattern and the at least
one diffraction grating pattern is arranged between the
first reference pattern and the second reference
pattern.

10 4. The evaluation mask according to claim 1,
wherein

15 the at least one diffraction grating pattern
include a first diffraction grating pattern and a
second diffraction grating pattern, and the reference
pattern is arranged between the first diffraction
grating pattern and the second diffraction grating
pattern.

5. The evaluation mask according to claim 1,
wherein

20 the at least one diffraction grating pattern
include a first diffraction grating pattern and a
second diffraction grating pattern, and the reference
pattern includes a first reference pattern and a second
reference pattern; and

25 the first diffraction grating pattern and the
first reference pattern being arranged in parallel with
each other on a first straight line, the second
diffraction grating pattern and the second reference

pattern being arranged in parallel with each other on a second straight line running perpendicularly relative to the first straight line.

5 6. The evaluation mask according to claim 1, further comprising:

a trim pattern; and

10 a part of the group of line pattern which comprises the image of the at least one diffraction grating pattern being covered with the image of the trim pattern when the trim pattern and the diffraction grating pattern are exposed to light and images of the trim pattern and the at least one diffraction grating pattern are superposed.

15 7. The evaluation mask according to claim 1, wherein

a plurality of pairs of the at least one diffraction grating pattern and the reference pattern are arranged rotationally at every 45° or 22.5°.

20 8. The evaluation mask according to claim 1, wherein

the diffraction grating pattern includes a light-shield section for shielding light and first and second transparent sections for transmitting light; and

25 the absolute value of the difference between a phase of light transmitted through the first transparent section and a phase of light transmitted through the second transparent section being other than

180°.

9. The evaluation mask according to claim 8,
wherein

the absolute value is equal to 90°.

5 10. An evaluation mask according to claim 9,
wherein

the ratio of the width of the light-shield section,
the width of the first transparent section and the
width of the second transparent section is
10 substantially 2 : 1 : 1.

11. An evaluation mask for evaluating a
projection-type exposure apparatus, the mask
comprising:

at least one diffraction grating pattern for
15 producing a diffracted light of the positive first-
order and a diffracted light of negative first-order,
diffraction efficiencies of the diffracted lights being
different respectively, one of the diffracted lights
having a magnitude that is substantially zero, the at
20 least one diffraction grating pattern comprising a
light-shield section for shielding light and first and
second transparent sections for transmitting light, the
absolute value of the difference between a phase of
light transmitted through the first transparent section
25 and a phase of light transmitted through the second
transparent section being 90°, and an image of the at
least one diffraction grating pattern being projected

onto a test substrate or an image detector by the projection-type exposure apparatus; and

5 a reference pattern for obtaining a reference image to measure a displacement of the image of the at least one diffraction grating pattern, and an image of the reference pattern being projected onto the test substrate or the image detector by the projection-type exposure apparatus,

10 wherein the images of the at least one diffraction grating pattern and the reference pattern projected onto the test substrate or the image detector are used for evaluating the projection-type exposure apparatus.

12. A focus measuring method for measuring a defocus of an image of a test mark formed on a focus test mark projected on a substrate, the image being projected by a projection-type exposure apparatus, the projection-type exposure apparatus projecting an image of a mask pattern formed in a photo mask onto the substrate by way of a projection optical system comprising:

20 preparing an evaluation mask as the focus test mark, the evaluation mask comprising: at least one diffraction grating pattern for producing a diffracted light of the positive first-order and a diffracted light of negative first-order, diffraction efficiencies of the diffracted lights being different respectively, 25 one of the diffracted lights having a magnitude that is

substantially zero, and a reference pattern for obtaining a reference image to measure a displacement of the image of the at least one diffraction grating pattern,

5 preparing a substrate with a photo sensitizing material;

 exposing the image of the diffraction grating pattern and the image of the reference pattern onto the substrate simultaneously, the diffraction grating
10 pattern and the reference pattern comprising a test mark in the evaluation mask;

 exposing an image of a trim pattern onto the substrate if the trim pattern exists in the evaluation mask; and

15 measuring the relative distance of the image of the diffraction grating pattern formed on the substrate and the image of the reference image formed on the substrate.

 13. The focus measuring method according to
20 claim 12, wherein

 the reference pattern is a diffraction grating pattern that is symmetric relative to the diffraction grating pattern.

 14. The focus measuring method according to
25 claim 12, wherein

 the reference pattern includes a first reference pattern and a second reference pattern and the at least

one diffraction grating pattern is arranged between the first reference pattern and the second reference pattern.

15. The focus measuring method according to
5 claim 12, wherein

the at least one diffraction grating pattern
include a first diffraction grating pattern and a
second diffraction grating pattern and the reference
pattern is arranged between the first diffraction
10 grating pattern and the second diffraction grating
pattern.

16. The focus measuring method according to
claim 12, wherein

the at least one diffraction grating pattern
15 include a first diffraction grating pattern and a
second diffraction grating pattern and the reference
pattern includes a first reference pattern and a second
reference pattern; and

the first diffraction grating pattern and the
20 first reference pattern being arranged in parallel with
each other on a first straight line, the second
diffraction grating pattern and the second reference
pattern being arranged in parallel with each other on a
second straight line running perpendicularly relative
25 to the first straight line.

17. A focus measuring method for measuring a
defocus of an image of a test mark formed on a focus

test mark projected on a substrate, the image being
projected by a projection-type exposure apparatus, the
projection-type exposure apparatus projecting an image
of a mask pattern formed in a photo mask onto the
5 substrate by way of a projection optical system
comprising:

preparing an evaluation mask as the focus test
mark, the evaluation mask comprising: at least one
diffraction grating pattern for producing a diffracted
10 light of the positive first-order and a diffracted
light of negative first-order, diffraction efficiencies
of the diffracted lights being different respectively,
one of the diffracted lights having a magnitude that is
substantially zero, and a reference pattern for
15 obtaining a reference image to measure a displacement
of the image of the at least one diffraction grating
pattern; and

measuring the relative distance of the image of
the diffraction grating pattern formed on the substrate
20 and the image of the reference image formed on the
substrate.

18. A focus measuring method for measuring a
defocus of an image of a test mark formed on a focus
test mark projected on a substrate, the image being
25 projected by a projection-type exposure apparatus, the
projection-type exposure apparatus projecting an image
of a mask pattern formed in a photo mask onto the

substrate by way of a projection optical system
comprising:

preparing an evaluation mask as the focus test
mark, the evaluation mask comprising at least one
5 diffraction grating pattern for producing a diffracted
light of the positive first-order and a diffracted
light of negative first-order, diffraction efficiencies
of the diffracted lights being different respectively,
one of the diffracted lights having a magnitude that is
10 substantially zero, the at least one diffraction
grating pattern comprising a light-shield section for
shielding light and first and second transparent
sections for transmitting light, the absolute value of
the difference between a phase of light transmitted
15 through the first transparent section and a phase of
light transmitted through the second transparent
section being 90° , and a reference pattern for
obtaining a reference image to measure a displacement
of the image of the at least one diffraction grating
20 pattern; and

measuring the relative distance of the image of
the diffraction grating pattern formed on the substrate
and the image of the reference image formed on the
substrate.

25 19. An aberration measuring method for measuring
an aberration of a projection-type exposure apparatus
based on a defocus of an image of a test mark formed on

a focus test mark projected on a substrate, the image being projected by the projection-type exposure apparatus, the projection-type exposure apparatus projecting an image of a mask pattern formed in a photo mask onto the substrate by way of a projection optical system comprising:

preparing an evaluation mask as the focus test mark, the evaluation mask comprising: at least one diffraction grating pattern for producing a diffracted light of the positive first-order and a diffracted light of negative first-order, diffraction efficiencies of the diffracted lights being different respectively, one of the diffracted lights having a magnitude that is substantially zero, and a reference pattern for obtaining a reference image to measure a displacement of the image of the at least one diffraction grating pattern,

preparing a substrate with a photo sensitizing material;

exposing the image of the diffraction grating pattern and the image of the reference pattern onto the substrate simultaneously, the diffraction grating pattern and the reference pattern comprising a test mark in the evaluation mask under the condition of $\lambda / \{NA (1 - \sigma)\} \leq P \leq 2 \leq \lambda / \{NA (1 + \sigma)\}$, where σ is a partial coherence of a lighting optical system for lighting the test mark, P is a period of the image of

the first pattern of the test mark, λ is the wavelength of light of the lighting optical system and NA is a numerical aperture of the projection optical system;

5 exposing an image of a trim pattern onto the substrate if the trim pattern exists in the evaluation mask; and

measuring the relative distance of the image of the diffraction grating pattern formed on the substrate and the image of the reference image formed on the substrate.

20. An aberration measuring method according to claim 19, wherein

the reference pattern is a diffraction grating pattern that is symmetric relative to the diffraction grating pattern.

21. An aberration measuring method according to claim 19, wherein

the reference pattern includes a first reference pattern and a second reference pattern and the diffraction grating pattern is arranged between the first reference pattern and the second reference pattern.

22. An aberration measuring method according to claim 19, wherein

the diffraction grating pattern include a first diffraction grating pattern and a second diffraction

grating pattern and the reference pattern is arranged between the first diffraction grating pattern and the second diffraction grating pattern.

23. An aberration measuring method according to
5 claim 19, wherein

the diffraction grating pattern include a first
diffraction grating pattern and a second diffraction
grating pattern and the reference pattern includes a
first reference pattern and a second reference pattern;
10 and

the first diffraction grating pattern and the
first reference pattern being arranged in parallel with
each other on a first straight line, the second
diffraction grating pattern and the second reference
15 pattern being arranged in parallel with each other on a
second straight line running perpendicularly relative
to the first straight line.